A4

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : A61B 17/70

A1

(11) International Publication Number: **WO 00/19923**

(43) International Publication Date: 13 April 2000 (13.04.00)

(21) International Application Number: PCT/US99/22860

(22) International Filing Date: 4 October 1999 (04.10.99)

(30) Priority Data:
09/167,439 6 October 1998 (06.10.98) US

(71) Applicant: SURGICAL DYNAMICS, INC. [US/US]; 111 Glover Avenue, Norwalk, CT 06856 (US).

(72) Inventor: YUAN, Hansen; 5066 Pine Valley Drive, Fayetteville, NY 13066 (US).

(74) Agent: GERSHON, Neil, D.; United States Surgical, 150 Glover Avenue, Norwalk, CT 06856 (US).

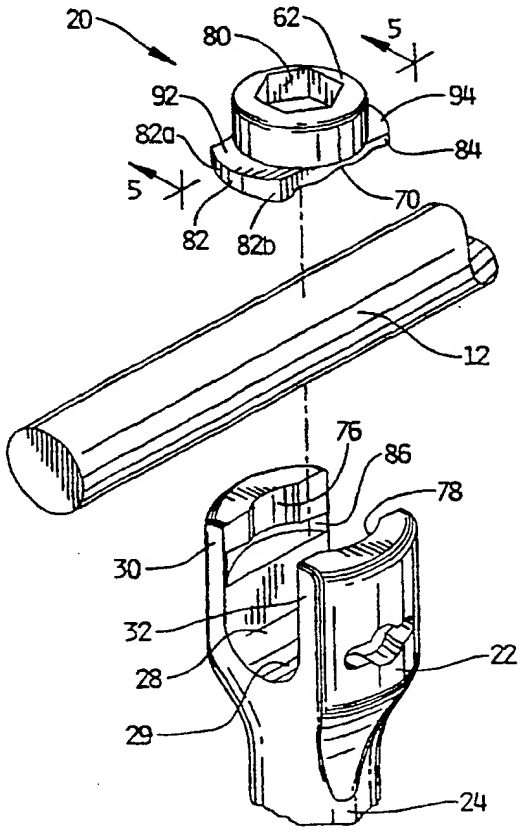
(81) Designated States: AU, CA, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: DEVICE FOR SECURING SPINAL RODS

(57) Abstract

A device is disclosed for securing a spinal rod to the spine which includes a head portion configured to receive a spinal rod, a locking cap configured to engage the head portion and the spinal rod upon rotation of the locking cap relative to the head portion to secure the position of the head portion relative to the spinal rod, and a fastener portion depending from the head portion and configured to engage the spine.



UA

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Larvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

DEVICE FOR SECURING SPINAL RODS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject disclosure relates to implantable spinal stabilization systems for surgical treatment of spinal disorders, and more particularly, to a device for connecting cylindrical spinal rods of a spinal stabilization system to the spine.

2. Background of the Related Art

The spinal column is a complex system of bones and connective tissue which protects critical elements of the nervous system. Despite these complexities, the spine is a highly flexible structure, capable of a high degree of curvature and twist through a wide range of motion. Trauma or developmental irregularities can result in spinal pathologies which limit this range of motion.

For many years, orthopedic surgeons have attempted to correct spinal irregularities and restore stability to traumatized areas of the spine through immobilization. Over the past ten years, spinal implant systems have been developed to achieve immobilization. Examples of such systems are disclosed in U.S. Patent Nos. 5,102,412 and 5,181,917 to Rogozinski. Such systems often include spinal instrumentation having connective structures such as elongated rods which are placed on opposite sides of the portion of the spinal column intended to be immobilized. Screws and hooks are commonly utilized to facilitate segmental attachment of such connective structures to the posterior surfaces of the spinal laminae, through the pedicles, and into

the vertebral bodies. These components provide the necessary stability both in tension and compression to achieve immobilization.

Various fastening mechanisms have been provided in the prior art to facilitate securement of screws and hooks to the connective structures of a spinal stabilization system. For example, U.S. Patent No. 5,257,993 to Asher discloses an apparatus for use in retaining a spinal hook on an elongated spinal rod. The apparatus includes a body extending upwardly from a hook portion and having an open ended recess for receiving a spinal rod and an end cap engageable with the body to close the recess. A set screw is disposed in the center of the end cap to clamp the rod in the recess of the body. The end cap and body are interconnectable by different types of connectors including a bayonet connector, a linear cam connector or a threaded connector. Other examples of fastening mechanism for facilitating attachment of screws and hooks to the connective structures of a spinal stabilization system are disclosed in U.S. Patent No. 5,437,669 to Yuan et al. and U.S. Patent No. 5,437,670 to Sherman et al.

In each of these prior art examples, threaded fasteners are used to facilitate securement of the connector to the spinal rod. Yet it is well known that threaded fasteners can become loosened under the influence of cyclically applied loads commonly encountered by the spinal column. Furthermore, during assembly, excessive torque applied to a threaded fastener can cause damage to the fastener as well as to the connective device with which it is associated.

It would be beneficial to provide a more reliable and effective mechanism for facilitating the attachment of screws, hooks and clamps to the connective structures of a spinal stabilization system.

SUMMARY OF THE DISCLOSURE

The subject disclosure is directed to a device for securing a spinal rod to a fixation device such as a pedicle screw or a lamina hook. The device disclosed herein includes a head portion configured to receive a spinal rod, a locking cap configured to engage the head portion and the spinal rod upon rotation of the locking cap relative to the head portion to secure the position of the head portion relative to the spinal rod, and a fastener portion extending from the head portion and configured to engage the spine. The fastener portion of the device can be in the form of a screw, hook or clamp, or any other configuration known in the art.

The head portion of the device has a channel extending therethrough for receiving a spinal rod and the channel is preferably bounded by opposed side walls each having an arcuate engagement slot defined therein. The locking cap preferably has opposed arcuate engagement flanges configured for reception in the opposed arcuate engagement slots of the head portion upon rotation of the locking cap relative to the head portion. Preferably, the opposed engagement slots are each defined in part by inclined slot surfaces, with the angle of the inclined surface of one engagement slot being opposite that of the opposed engagement slot. Similarly, the opposed engagement flanges are preferably each defined in part by inclined flange surfaces, with the angle of the inclined surface of one engagement flange being opposite that of the opposed engagement flange. The head portion also preferably includes structure for interacting with the locking cap to prevent the opposed side walls of the head portion from expanding radially outwardly when the arcuate flanges are engaged in the arcuate slots.

Preferably, the locking cap of the device is configured for rotation between an initial position in which the arcuate engagement flanges are 90° out of phase with the arcuate engagement slots, an intermediate position in which the arcuate engagement

flanges are 45° out of phase with the arcuate engagement slots, and a locked position in which the arcuate engagement flanges are in phase and intimately engaged with the arcuate engagement slots.

In this regard, the bottom surface of the locking cap preferably includes a first recess oriented to accommodate a spinal rod when the locking cap is in an initial unlocked position, a second recesses which intersects the first recess at a first angle to accommodate a spinal rod when the locking cap is in an intermediate position, and a third recess which intersects the elongate recess at a second angle to accommodate a spinal rod when the locking cap is in a final locked position. In accordance with a preferred embodiment of the subject disclosure, the first recess is an elongate recess, the second recess is a transverse recess which intersects the elongate recess at a 45° angle, and the third recess is an orthogonal recess which intersects the elongate recess at a 90° angle.

These and other unique features of the device disclosed herein and the method of installing the same will become more readily apparent from the following description of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

So that those having ordinary skill in the art to which the disclosed apparatus appertains will more readily understand how to construct and use the same, reference may be had to the drawings wherein:

Fig. 1 is a perspective view of an elongated spinal rod of a spinal stabilization system having attached thereto a bone screw and a bone hook constructed in accordance with a first embodiment of the subject disclosure;

Fig. 2 is a perspective view of a locking cap which forms part of the bone screw and bone hook illustrated in Fig. 1, oriented in an inverted position for ease of illustration;

Fig. 3 is a perspective view of the bone screw and locking cap of Fig. 1 separated from one another for ease of illustration;

Fig. 4 is a cross-sectional view of the bone screw of the subject disclosure taken along line 4-4 of Fig. 1;

Fig. 5 is a cross-sectional view of the locking cap taken along line 5-5 of Fig. 3;

Figs. 6A through 6D illustrate operative steps associated with attaching the bone fastener of the subject disclosure to a spinal rod, wherein:

Fig. 6A illustrates the step of positioning the spinal rod and locking cap in the reception channel of the head portion of a fastening device of the subject disclosure;

Fig. 6B illustrates the initial orientation of the locking cap relative to the head portion of a fastening device of the subject disclosure wherein the locking cap is in an unlocked position;

Fig. 6C illustrates the rotation of the locking cap relative to the head portion of a fastening device of the subject disclosure to a partially locked position; and

Fig. 6D illustrates the rotation of the locking cap relative to the head portion of a fastening device of the subject disclosure to a locked position;

Fig. 7 is a perspective view of a fastening device constructed in accordance with a second embodiment of the subject disclosure;

Fig. 8 is a perspective view of the fastening device of Fig. 7 with the locking cap separated for ease of illustration;

Fig. 9 is a perspective view of the locking cap of the fastener device of

Fig. 7, oriented in an inverted position for ease of illustration; and

Fig. 10 is a cross-sectional view of the fastening device of Fig. 7 taken along line 10-10 of Fig. 7.

These and other features of the apparatus disclosed herein will become more readily apparent to those having ordinary skill in the art from the following detailed description of the preferred embodiments taken in conjunction with the drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings wherein like reference numerals identify similar structural elements of the subject apparatus, there is illustrated in Fig. 1 a section of a spinal stabilization system constructed in accordance with a preferred embodiment of the subject disclosure and designated generally by reference numeral 10.

Referring to Fig. 1, spinal stabilization system 10 includes an elongated spinal rod 12 having a circular cross-section and a substantially smooth outer surface finish. As illustrated, fastening devices in the form of a bone screw 14 and right-angle hook 16 are provided for securing spinal rod 12 to the spine during a spinal stabilization procedure. Both fastening devices employ a novel top-loaded locking cap, designated generally by reference numeral 20, which will be described in greater detail hereinbelow with reference to Fig. 2. The novel locking cap achieves significant clinical advantages over the prior art through its reliability and the ease in which it is installed during a spinal stabilization procedure.

It should be recognized that the subject disclosure is not limited in any way to the illustrated bone screw and right-angle hook. Rather, these particular fasteners are merely examples of the type of devices that can employ the novel locking cap disclosed herein. Other fasteners commonly utilized in spinal stabilization systems, such

as, for example, hooks having alternative angular geometries as well as clamps are also envisioned. Indeed, it is envisioned that any component designed for attachment to an elongated spinal rod or transverse coupling rod, may incorporate the novel locking cap of the subject disclosure. Also, any number of fastening devices can be applied along the length of the spinal rod.

With continuing reference to Fig. 1, bone screw 14 includes a head portion 22 defining a horizontal axis and a vertical axis. A shank portion 24 depends from the head portion and a threaded portion 26 having a helical thread extending about the outer periphery depends from the shank portion. The helical thread is particularly adapted to securely engage the vertebral bodies of the spine. A channel 28 extends through the head portion 22 along the horizontal axis thereof for receiving elongated spinal rod 12. As best seen in Fig. 3, channel 28 is defined by the interior surfaces of side walls 30 and 32 and the curved lower surface 29 which extends therebetween. Locking cap 20 is dimensioned and configured for reception and engagement in locking channel 28 to secure the position of bone screw 14 with respect to spinal rod 12 during a spinal stabilization procedure.

Referring again to Fig. 1, right-angle hook 16 includes a head portion 42 defining a horizontal axis and a vertical axis. A hook portion 46 depends from the head portion 42 for securement to a vertebral body of the spine. A channel 48 extends through the head portion 22 along the horizontal axis thereof for receiving elongated spinal rod 12. Channel 48 is defined by the interior surfaces of opposed side walls 50 and 52 and a curved lower surface extending therebetween. Locking cap 20 is dimensioned and configured for reception and engagement in channel 48 to secure the position of hook 16 with respect to spinal rod 12 during a spinal stabilization procedure.

Referring now to Fig. 2, there is illustrated locking cap 20 in an inverted position to best illustrate structural aspects thereof. Locking cap 20 includes a cylindrical

head 62 and a flanged portion 64. The bottom surface 66 of flanged portion 64 includes an elongate recess 68 having a curvature complementary to spinal rod 12 for accommodating the spinal rod when locking cap 20 is in an unlocked position, shown for example in Fig. 6B. In such a position, the fastening device may be moved freely along or rotated about the longitudinal axis of the spinal rod. Bottom surface 66 also includes a bifurcated orthogonal recess 70 which intersects the elongate recess at a 90° angle and has a curvature complementary to spinal rod 12 to accommodate the spinal rod when locking cap 20 is in a locked position, shown for example in Fig. 6D and Fig. 4. In addition, bottom surface 66 includes bifurcated first and second transverse recesses 72 and 74 which intersect the elongate recess 68 at opposite angles of intersection and have curvatures which are complementary to spinal rod 12 to accommodate the spinal rod when the locking cap 20 is in either of two intermediate positions, one of which is shown for example in Fig. 6C. In such a position, the fastening device retains the spinal rod but is not fully secured, and if desired by the surgeon, locking cap 20 can be rotated from the intermediate position and the fastener moved to an alternative location on the spinal rod. Preferably, the transverse recesses intersect the elongate recess at opposed 45° angles. However, those skilled in the art will readily appreciate that the transverse recess can be oriented at alternative intersecting angles. It is also contemplated that the bottom surface can be flat without any recesses.

Referring to Figs. 3 and 5, the cylindrical head 62 of locking cap 20 includes a hexagonal axial bore 80 extending partially therethrough for receiving a working implement such as a wrench to facilitate rotation of the locking cap 20 relative to the head portion 22 of the fastening device about the vertical axis defined thereby. It envisioned that alternative tooling configurations known in the art can also be utilized to facilitate axial rotation of locking cap 20 during a surgical procedure. Curved notches 76

and 78 are formed in the inner surfaces of opposed walls 30 and 32 for accommodating the cylindrical head 62 of locking cap 20 when the locking cap is received and rotated within channel 28.

The flanged portion 64 of locking cap 20 is defined in part by two diametrically opposed arcuate engagement flanges 82 and 84 which are dimensioned and configured for operative engagement with two complementary diametrically opposed arcuate engagement slots 86 and 88 defined in the interior surfaces of the opposed side walls 30 and 32 of head portion 22. (See Fig. 4).

With continuing reference to Figs. 3 through 5, engagement flanges 82 and 84 define ramped camming surfaces 92 and 94, respectively. Camming surfaces 92 and 94 are of opposite angular inclination with respect to one another. More particularly, each engagement flange has a low side (e.g., 82a of flange 82) and a high side (e.g., 82b of flange 82), whereby the low sides of the two flanges are diametrically opposed from one another as are the high sides. Actually, the camming surfaces of the flanges are mirror images of one another. Thus, the locking cap can be initially oriented with either flange aligned to engage either slot. This versatility adds to the ease in which the locking cap is installed during a surgical procedure.

As best seen in Fig. 4, the arcuate engagement slots 86 and 88 in head portion 22 of fastener 14 have inclined surfaces which mate with the ramped camming surfaces 92 and 94 of flanges 82 and 84. As best seen in Fig. 5, the ramped camming surfaces 92 and 94 are tapered radially inwardly to enhance the interlock with the mating surfaces of arcuate engagement slots 86 and 88, which are also tapered to complement the radially inward taper of camming surfaces 92 and 94. This interlocking relationship serves to prevent the opposed side walls 30 and 32 of head portion 22 from spreading

radially outward as the arcuate flanges are engaged with the arcuate slots when the locking cap 20 is rotated to a locked position.

Figs 6A through 6D illustrate the steps in securing the fastening device to the spinal rod during a surgical procedure. Although attachment of a bone screw 14 is shown, it should be understood, as noted above, that other fastening devices, e.g., bone hooks, can be secured to the spinal rod 12 using the locking cap and head portion structure of the present disclosure. Initially, as illustrated in Fig. 6A, spinal rod 12 is moved into approximation with the horizontal channel 28 of head portion 22 such that the periphery of the spinal rod 12 is in registration with the curved surface 29 of the channel 28. Locking cap 20 is then top loaded into the channel along the vertical axis of the fastener in the direction of arrow a. At such a time, spinal rod 12 is accommodated within the elongate recess 68 defined in the bottom surface 66 of locking cap 20 and the bone screw 14 may be moved freely relative to the spinal rod. The opposed flanged sections 82 and 84 of locking cap 20 are 90° out of phase from the opposed arcuate engagement slots 86 and 88 defined in head portion 22, as shown for example in Fig. 6B.

Thereafter, as shown in Fig. 6C, locking cap 20 is rotated 45° relative to head portion 22 about the vertical axis thereof. At such a time, spinal rod 12 is accommodated within one of the two transverse recesses 72 or 74, depending upon the initial orientation of the locking cap 20 with respect to the head portion. Thereupon, the opposed arcuate engagement flanges 82 and 84 of locking cap 20 are only partially engaged with the opposed arcuate engagement slots 86 and 88 defined in head portion 22, as they are 45° out of phase with the slots. Consequently, the locking cap holds the fastener 22 and spinal rod 12 together, but does not lock the fastener. In this position, the locking cap 20 can be readily rotated in the opposite direction to disengage from the spinal rod 12 to adjust the position of the bone screw 14 with respect to the spinal rod 12.

Once the desired position and orientation of the bone screw 14 has been attained, locking cap 20 is rotated another 45° to the locked position illustrated in Fig. 6D. At such a time, spinal rod 12 is accommodated within the orthogonal recess 70 defined in the bottom surface of locking cap 20. Thereupon, the opposed engagement flanges 82 and 84 of flanged portion 64 are fully engaged with the opposed engagement slots 86 and 88 of head portion 22, and the longitudinal and angular orientations of the bone screw 14 are fixed with respect to spinal rod 12, as illustrated in Fig. 4. It should be readily apparent that the manner and method by which bone screw 14 hook is attached to spinal rod 12 is identical to the manner and method by which hook 16 or other fasteners are attached to spinal rod 12.

Since the rotational range of locking cap 20 is limited, i.e., the locking cap can only be rotated 90°, it will be readily appreciated that the cap cannot be over-torqued. Thus, the damage often caused by over-tightening a conventional threaded locking mechanism, such as a set screw, is avoided. Furthermore, since the locking cap of the subject disclosure has a predetermined locked position, it is unlikely that it will be under-torqued or left in a loose condition after installation as is common with threaded set screws found in the prior art. That is, by having a predetermined locked position, uniform locking forces are provided for all of the fastening devices used to secure the spinal rod 12 along its length and cross threading is reduced.

Referring now to Figs. 7 and 8, there is illustrated another fastening device constructed in accordance with a preferred embodiment of the subject disclosure and designated generally by reference numeral 110. Fastening device 110 is similar to fastening devices 12 and 14 in that it is particularly designed to facilitate securement of a spinal rod to the spine in a convenient manner. Fastening device 110 includes a head portion 122 having opposed side walls 130 and 132 which define a horizontal channel

128 in conjunction with the curved lower surface 129 extending therebetween. Arcuate tabs 176 and 178 project upwardly from side walls 130 and 132, respectively, for interacting with locking cap 120.

Referring to Fig. 9, locking cap 120, which is shown in an inverted position for ease of illustration, includes a hexagonal head 162, a cylindrical body 163 and a flanged portion 164. The hexagonal head 162 is adapted and configured for interaction with a wrench or similar work implement. An annular channel 165 extends into the bottom surface of hexagonal head 162 for receiving arcuate tabs 176 and 168. This positive interaction serves to prevent the opposed side walls 130 and 132 of head portion 122 from spreading radially outwardly when arcuate flanges 182 and 184 of locking cap 120 are engaged in arcuate slots 186 and 188 of head portion 122 upon rotation of locking cap 20 into a locked position. Thus, in this embodiment, the ramped camming surfaces 192 and 194 of the arcuate engagement flanges 182 and 184 need not be provided with radially inwardly directed tapers as provided on flanges 82 and 84 of the locking cap 20 of the embodiment of Figs. 1-6.

With continuing reference to Fig. 9, the bottom surface 166 of the flanged portion 164 of locking cap 120 is configured in substantially the same manner as the bottom surface 66 of locking cap 20 in that it is provided with an elongate recess 168 for accommodating a spinal rod when the locking cap 120 is in an unlocked position, first and second bifurcated transverse recesses 172 and 174 which intersect the elongate recess 168 at opposite 45° angles to accommodate the spinal rod when the locking cap 120 is in either of two intermediate positions, and a bifurcated orthogonal recess 170 which intersects the elongate recess at a 90° angle to accommodate the spinal rod when the locking cap 120 is in a final locked position, as shown in Fig. 10. It will be readily appreciated that locking cap 120 is engaged with fastening device 110 in a manner that is

substantially similar to the manner in which locking cap 20 is engaged with bone fastener 14 and hook 16, and that the configuration of the bottom surface of flanged portion 164 provides the same benefits afforded by the flanged portion 64 of locking cap 20.

Although the apparatus disclosed herein has been described with respect to preferred embodiments, it is apparent that modifications and changes can be made thereto without departing from the spirit and scope of the invention as defined by the claims.

WHAT IS CLAIMED IS:

1. A device for securing a spinal rod to the spine comprising:

a) a head portion configured to receive a spinal rod;

b) a locking cap configured to engage the head portion and the spinal rod upon rotation of the locking cap relative to the head portion to secure the position of the head portion relative to the spinal rod; and

c) a fastener portion depending from the head portion and configured to engage the spine.

2. A device as recited in Claim 1, wherein the head portion has a channel extending therethrough for receiving a spinal rod and the channel is bounded by opposed side walls.

3. A device as recited in Claim 2, wherein each of the opposed side walls has an arcuate engagement slot defined therein.

4. A device as recited in Claim 3, wherein the locking cap has opposed arcuate engagement flanges configured for reception in the opposed arcuate engagement slots of the head portion upon rotation of the locking cap relative to the head portion.

5. A device as recited in Claim 4, wherein the locking cap is configured for rotation between an initial position in which the arcuate engagement flanges are 90° out of phase with the arcuate engagement slots, an intermediate position in which the arcuate engagement flanges are 45° out of phase with the arcuate engagement slots and a locked position in which the arcuate engagement flanges are in phase and intimately engaged with the arcuate engagement slots.

6. A device as recited in Claim 5, wherein the bottom surface of the locking cap includes an elongate recess oriented to accommodate a spinal rod when the locking cap is in an initial position.

7. A device as recited in Claim 6, wherein the bottom surface of the locking cap includes an orthogonal recess which intersects the elongate recess at a 90° angle to accommodate a spinal rod when the locking cap is in a locked position.

8. A device as recited in Claim 6, wherein the bottom surface of the locking cap includes at least one transverse recesses which intersects the elongate recess at a 45° angle to accommodate a spinal rod when the locking cap is in an intermediate position.

9. A device as recited in Claim 1, wherein the locking cap has a cylindrical head which includes a hexagonal bore for receiving a work implement.

10. A device as recited in Claim 1, wherein the locking cap has a a hexagonal head configured for reception by a work implement.

11. A device as recited in Claim 3, wherein the opposed engagement slots are each defined in part by inclined slot surfaces, with the angle of the inclined slot surface of one engagement slot being opposite that of the opposed engagement slot, and wherein the opposed engagement flanges are each defined in part by inclined flange surfaces, with the angle of the inclined flange surface of one engagement flange being opposite that of the opposed engagement flange.

12. A device as recited in Claim 11, wherein the inclined slot surfaces and the inclined flange surfaces are angularly tapered to complement each other.

13. A device as recited in Claim 1, wherein the fastener portion is configured as a screw.

14. A device as recited in Claim 1, wherein the fastener portion is configured as a hook.

15. A device for securing a spinal rod to the spine comprising:

a) a head portion defining a vertical axis and a horizontal axis, and configured to receive a spinal rod along the horizontal axis;

b) a locking cap configured for reception by the head portion along the vertical axis and adapted to engage the head portion and the spinal rod upon rotation of the locking cap about the vertical axis to secure the position of the head portion relative to the spinal rod; and

c) a fastener portion depending from the head portion and configured to engage the spine.

16. A device for securing a spinal rod to the spine comprising:

a) a head portion having a channel extending therethrough for receiving a spinal rod;

b) a locking cap configured to cooperate with the channel and engage the spinal rod of the locking cap being rotatable relative to the head portion between an unlocked position and a locked position to secure the position of the head portion relative to the spinal rod; and

c) a fastener portion depending from the head portion and configured to engage the spine.

17. A device as recited in Claim 16, wherein the locking cap is configured for rotation from the unlocked position to a partially locked intermediate position.

18. A device as recited in Claim 16, wherein the channel is bounded by opposed side walls each having an arcuate engagement slot defined therein, and the locking cap has opposed arcuate engagement flanges configured for reception in the opposed arcuate engagement slots upon rotation of the locking cap into the locked position.

19. A device as recited in Claim 17, wherein the locking cap has a bottom surface which includes an elongate recess oriented to accommodate a spinal rod when the locking cap is in the unlocked position, an orthogonal recess which intersects the elongate recess at a 90° angle to accommodate a spinal rod when the locking cap is in the locked position, and at least one transverse recesses which intersects the elongate recess at a 45° angle to accommodate a spinal rod when the locking cap is in the partially locked intermediate position.

20. A device as recited in Claim 18, wherein the opposed engagement slots are each defined in part by inclined slot surfaces, with the angle of the inclined slot surface of one engagement slot being opposite that of the opposed engagement slot, and wherein the opposed engagement flanges are each defined in part by inclined flange

surfaces, with the angle of the inclined surface of one engagement flange being opposite that of the opposed engagement flange.

21. A device as recited in Claim 20, wherein the inclined slot surfaces and the inclined flange surfaces are angularly tapered to complement each other.

22. A device as recited in Claim 16, wherein the fastener portion is configured as a screw.

23. A device as recited in Claim 16, wherein the fastener portion is configured as a hook.

24. A device for securing a spinal rod to the spine comprising:

a) a head portion having a channel extending therethrough for receiving a spinal rod, the channel being bounded by opposed side walls, each side wall having an arcuate engagement slot defined therein,

b) a locking cap having a bottom surface configured to accommodate a spinal rod extending through the channel of the head portion and including opposed arcuate engagement flanges configured for reception in the opposed arcuate engagement slots of the head portion upon rotation of the locking cap relative to the head portion to secure the position of the head portion relative to the spinal rod; and

c) a fastener portion depending from the head portion and configured to engage the spine.

25. A device as recited in Claim 24, wherein the locking cap is configured for rotation between an initial position in which the arcuate engagement flanges are 90° out of phase with the arcuate engagement slots, an intermediate position

in which the arcuate engagement flanges are 45° out of phase with the arcuate engagement slots and a locked position in which the arcuate engagement flanges are in phase and intimately engaged with the arcuate engagement slots.

26. A device as recited in Claim 24, wherein the bottom surface of the locking cap includes a first recess oriented to accommodate a spinal rod when the locking cap is in the initial position.

27. A device as recited in Claim 24, wherein the bottom surface of the locking cap includes a second recess which intersects the first recess at a first angle to accommodate a spinal rod when the locking cap is in the locked position.

28. A device as recited in Claim 24, wherein the bottom surface of the locking cap includes a third recess which intersects the first recess at a second angle to accommodate a spinal rod when the locking cap is in the intermediate position.

29. A device as recited in Claim 26, wherein the first recess is an elongate recess.

30. A device as recited in Claim 27, wherein the second recess intersects the first recess at a 90° angle.

31. A device as recited in Claim 28, wherein the third recess intersects the first recess at a 45° angle.

32. A device as recited in Claim 24, wherein the channel is defined in part by a hemi-cylindrical seat for accommodating a cylindrical spinal rod.

33. A device as recited in Claim 24, wherein the locking cap includes a cylindrical head having a hexagonal bore defined therein for receiving a work implement.

34. A device as recited in Claim 33, wherein the opposed side walls of the head portion include opposed arcuate notches for accommodating the cylindrical head of the locking cap.

35. A device as recited in Claim 24, wherein an arcuate appendage projects upwardly from each side wall of the head portion to engage an annular recess formed in an upper portion of the locking cap.

36. A device as recited in Claim 35, wherein the upper portion of the locking cap has a hexagonal configuration for reception by a working implement.

37. A device as recited in Claim 24, wherein the opposed engagement slots are each defined in part by inclined slot surfaces, with the angle of the inclined slot surface of one engagement slot being opposite that of the opposed engagement slot, and the opposed engagement flanges are each defined in part by inclined flange surfaces, with the angle of the inclined flange surface of one engagement flange being opposite that of the opposed engagement flange.

38. A device as recited in Claim 37, wherein the inclined slot surfaces and the inclined flange surfaces are angularly tapered to complement each other.

39. A device as recited in Claim 24, wherein the fastener portion is configured as a bone screw.

40. A device as recited in Claim 24, wherein the fastener portion is configured as a bone hook.

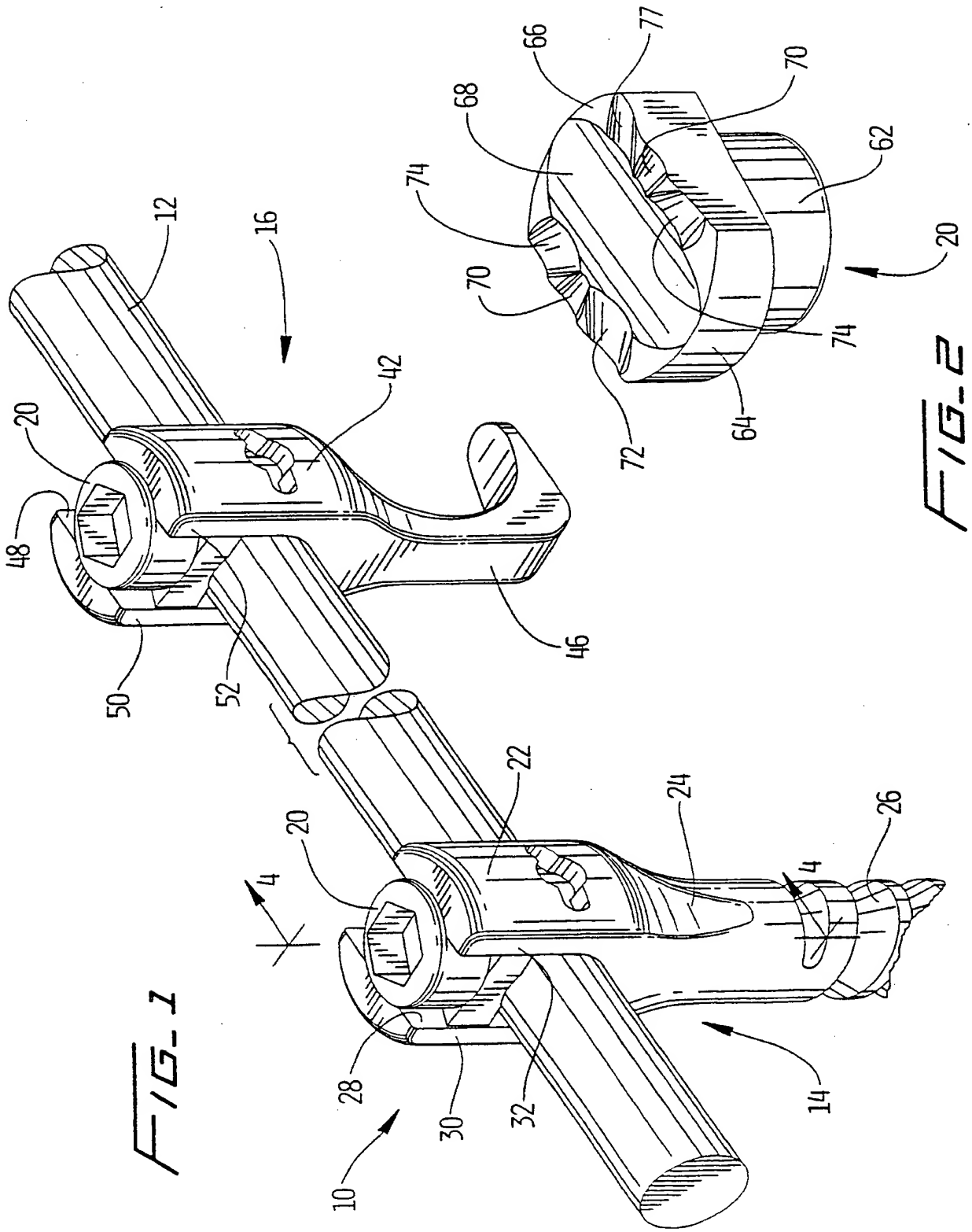


FIG_1

FIG_2

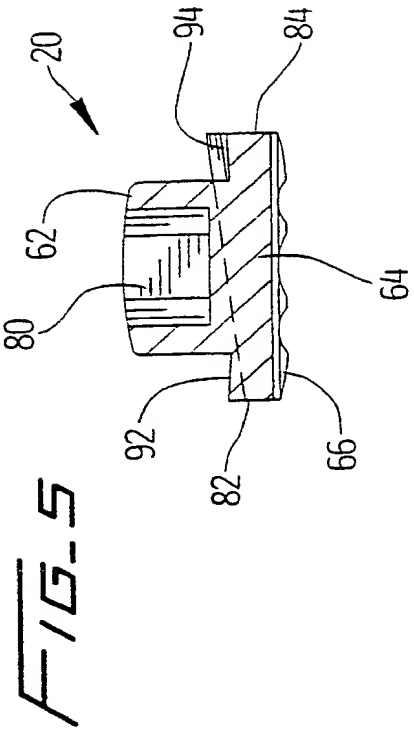


FIG_5

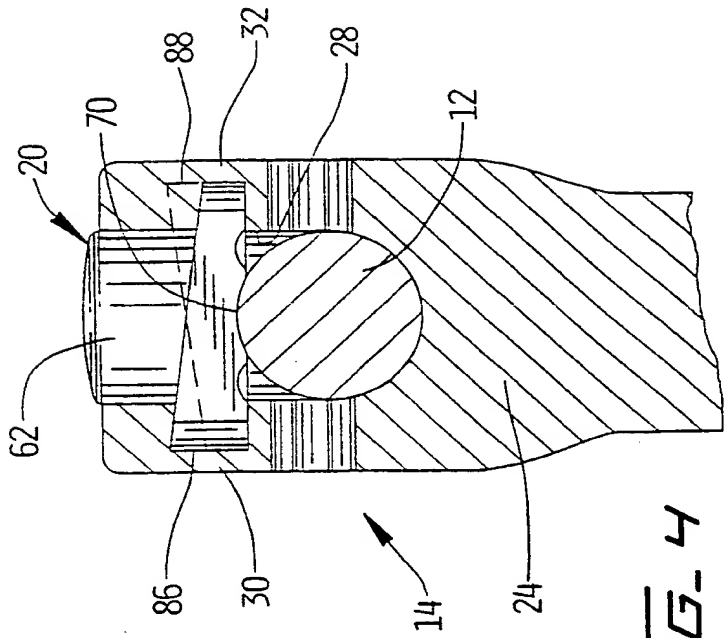


FIG_4

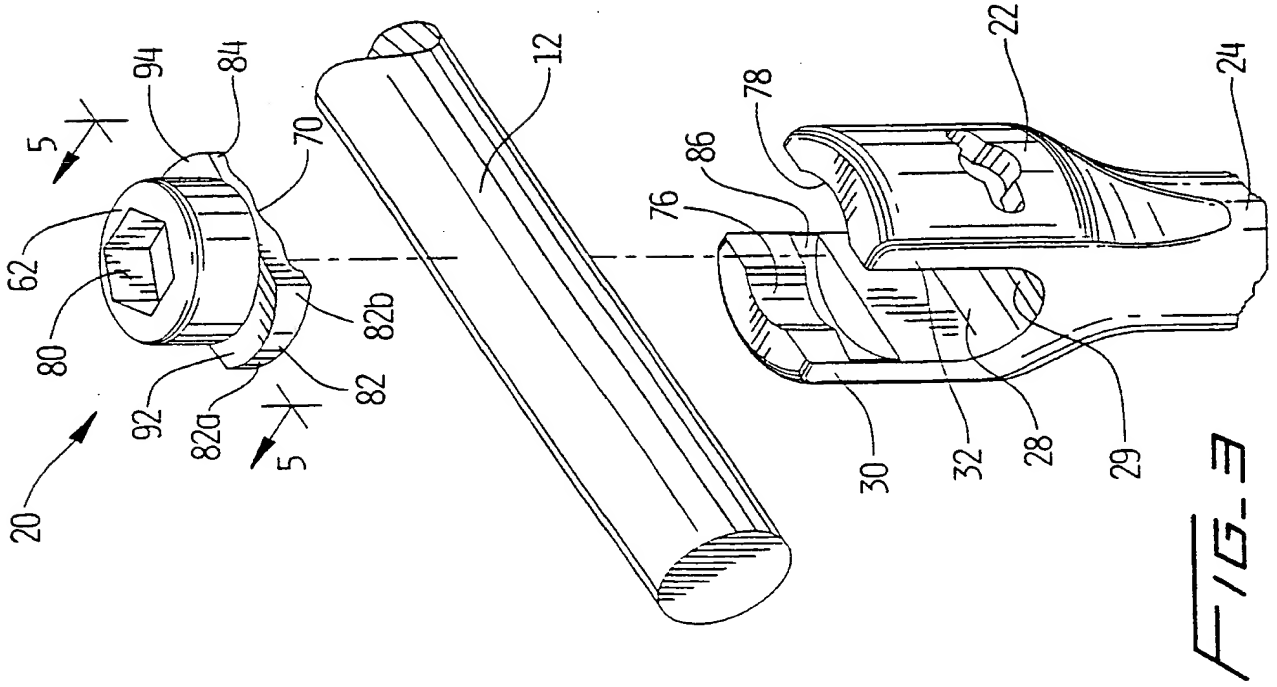


FIG_3

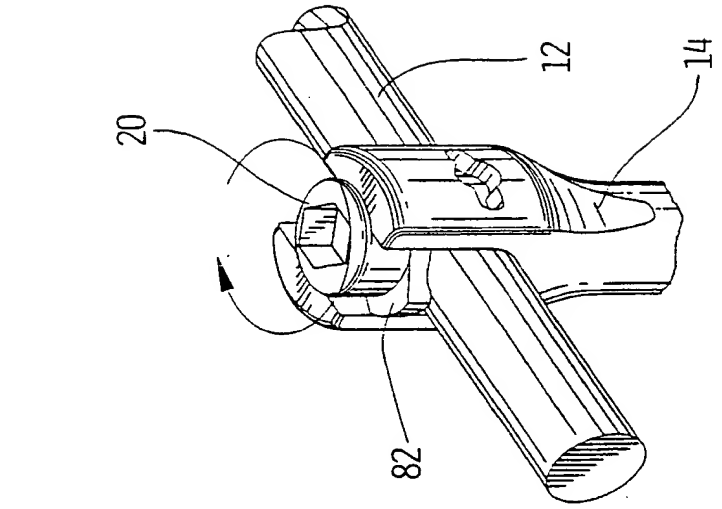


FIG_6C

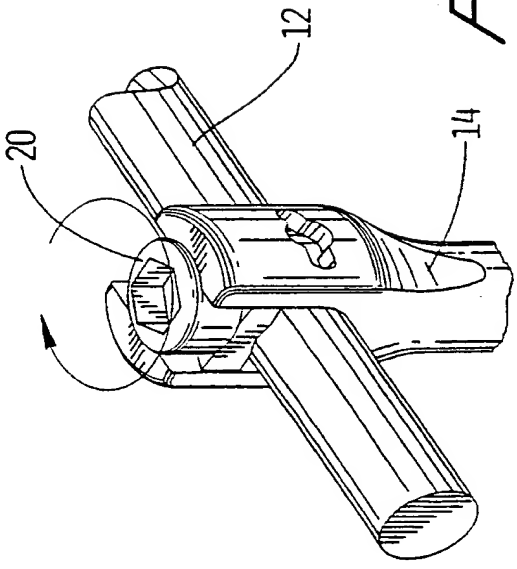


FIG_6D

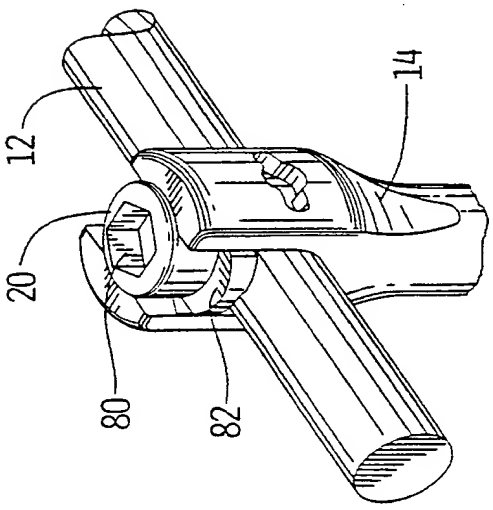


FIG_6B

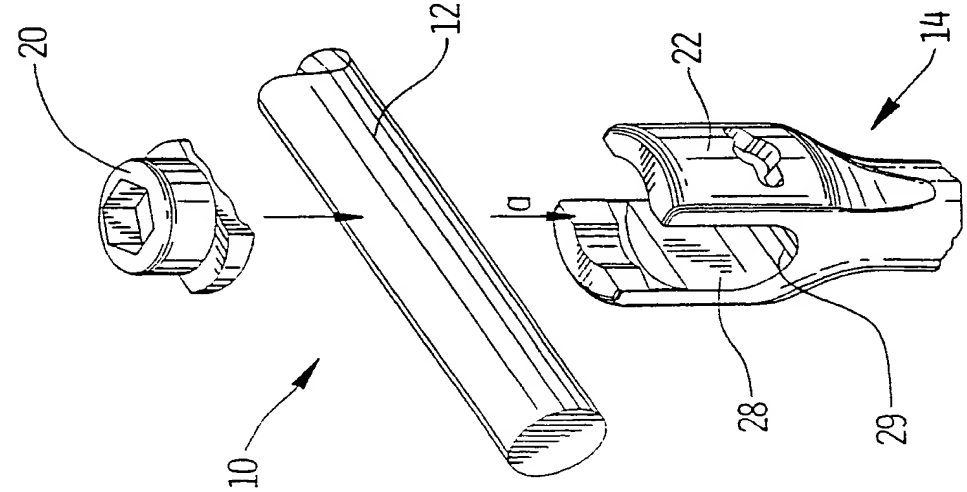


FIG_6A

FIG_ 7

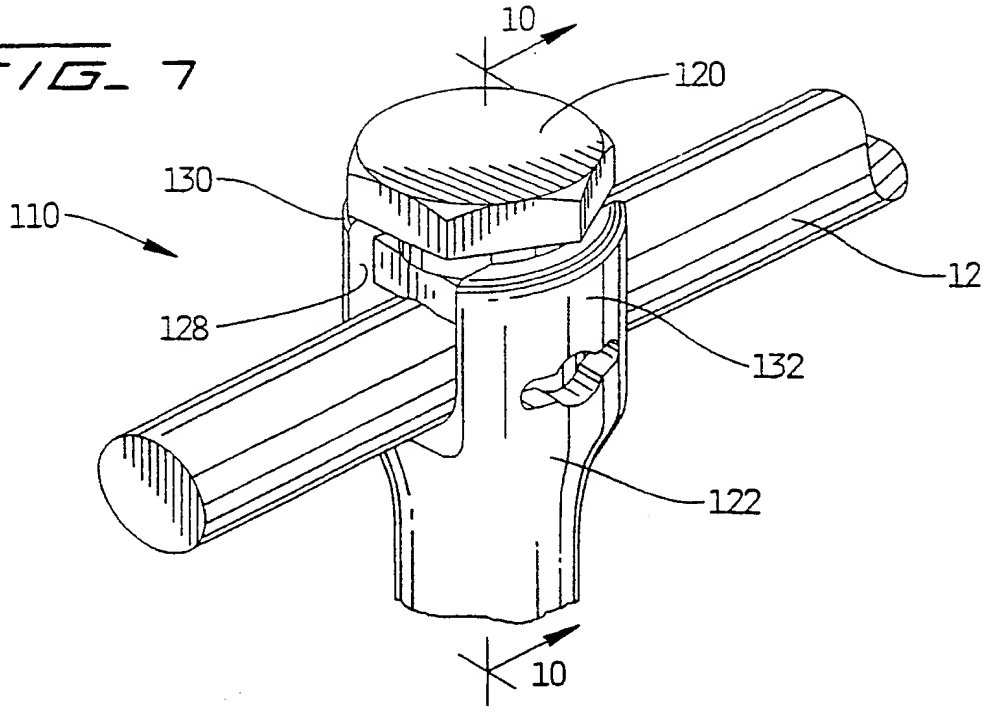
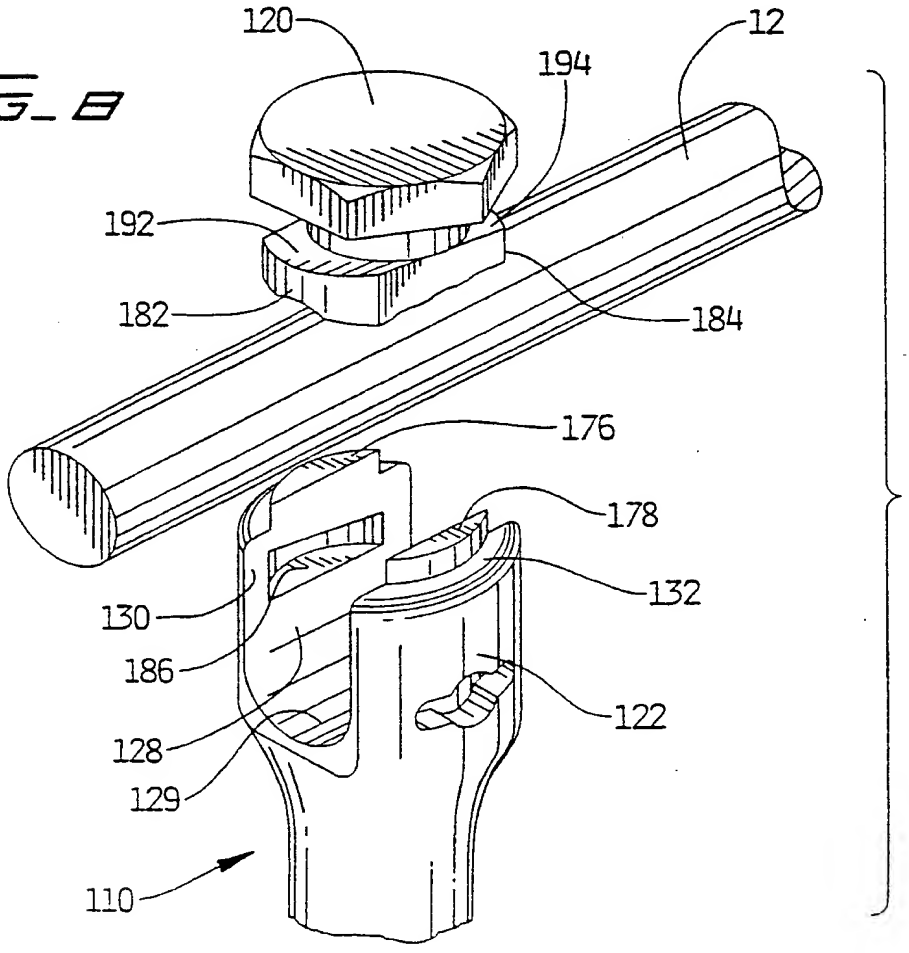


FIG_ 8



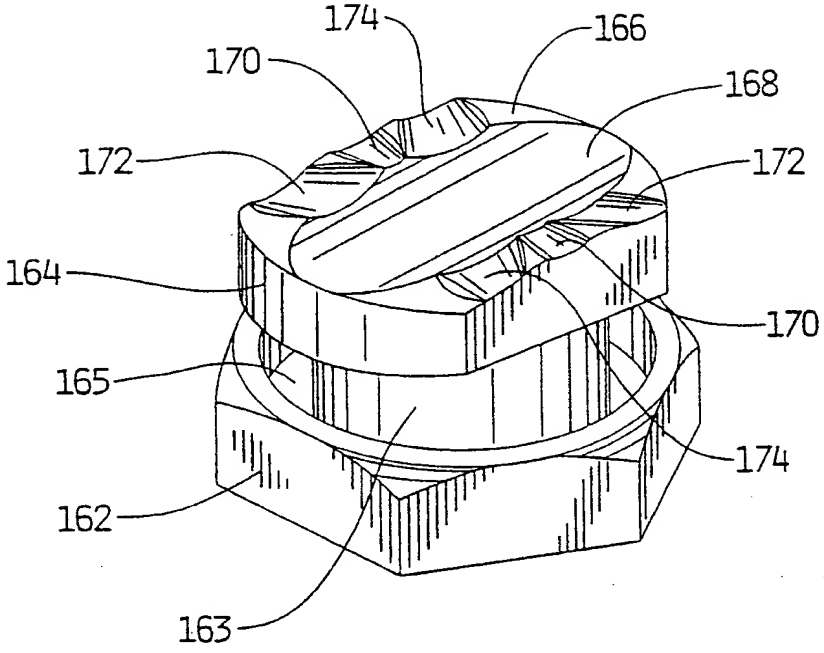


FIG_9

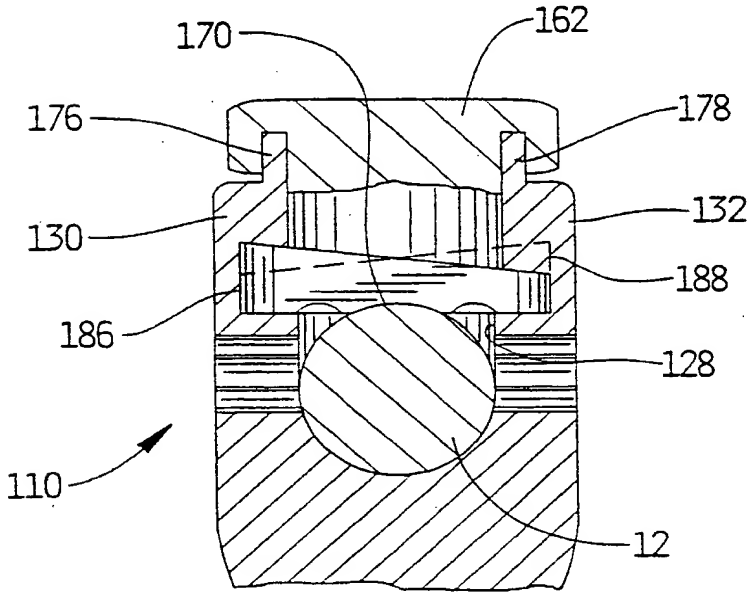


FIG_10

INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/US 99/22860

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B17/70

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 562 663 A (WISNEWSKI PAUL J ET AL) 8 October 1996 (1996-10-08)	1-4,13, 16,18, 22,24, 32,39
A	the whole document	5,6,15

X	DE 94 03 231 U (AESCULAP WERKE AG) 21 April 1994 (1994-04-21)	1,2,13, 15,16,22
A	the whole document	24,39

X	EP 0 535 623 A (ACROMED CORP) 7 April 1993 (1993-04-07) cited in the application	1,2, 14-16
A	the whole document	3-5,18, 23-25, 32,35,40

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 February 2000	10/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Verelst, P

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/22860

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5562663 A	08-10-1996	AU 5879696 A	30-12-1996
		EP 0836436 A	22-04-1998
		WO 9639972 A	19-12-1996
DE 9403231 U	21-04-1994	NONE	
EP 0535623 A	07-04-1993	US 5257993 A	02-11-1993
		AT 150633 T	15-04-1997
		CA 2079700 A	05-04-1993
		DE 69218534 D	30-04-1997
		DE 69218534 T	03-07-1997
		ES 2101779 T	16-07-1997
		HU 64816 A	28-03-1994
		JP 6125930 A	10-05-1994
		KR 9606057 B	08-05-1996
		US 5346493 A	13-09-1994
		ZA 9207521 A	20-07-1993